WET AND DRY PERIODS IN PUERTO RICO, 1899–1932

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This paper gives the chronological classification of wet and dry years that occurred in Puerto Rico from 1899 to 1932, inclusive. Following the plan of A. J. Henry's "The Calendar Year as a Time Unit in Drought Statistics" (MONTHLY WEATHER REVIEW, April 1931, vol. 59, pp. 150–154) the island is divided into sections—north, east, south, and west—in order to indicate the variations in rainfall in different parts of the area. In the south portion droughts are somewhat more frequent than in the east, owing to the east-west course of the mountains, which therefore cause the heavier rains to occur in the north and east parts of the island. Comparing the values, expressed in terms of percent of the normal, with similar data for the continental United States as given by Professor Henry, it is notable that while in 1930 the most severe drought on record was common alike to the United States and to Puerto Rico, the year 1933, though second in severity in the island was predominantly wet in large portions of the United States; in 17 divisions (State boundaries) it was one of the 10 wettest years of record although in some divisions it was one of the driest.

In 1907, which was the third driest year in the island, notably in the east portion, where the drought was 11 percent more severe than that of 1930, in terms of deficiency, rainfall in the continental United States was not generally subnormal, but on the contrary, established records for excessive amounts which made this one of the 10 wettest years in 10 divisions, though for 2 divisions it was one of the 10 driest years. There seems, therefore, to be no well-defined relationship between the rainfall of Puerto Rico and that of the United States, except perhaps in years of wide-spread and severe drought.

The comparative figures for the island from 1899 to 1932, shown in percentage of the normal, are given in tables 1, 2, and 3. As will be noted, tables 1 and 2 give the percentages of the normal by years in relative order from 1 to 10. Thus under group 1 is listed the year of least rainfall and percent of the normal for each of the four divisions, and for the island as a whole; under group 2 the year having the second lightest rainfall for each division, etc. A selected list or group of stations was chosen, as follows: North, 24 stations; south, 10 stations; west, 8 stations; east, 4 stations. Data for this selected list are practically unbroken for the given 34 years, and from them division normals were established.

Following the 1930 drought the years 1931 and 1932 were marked by excessive rainfall in the island. In 1931 the heaviest rainfall in 34 years was registered in the east portion and the second greatest in the south, while the island as a whole received the second greatest on record. In 1932 rainfall varied from the fifth heaviest in the east portion to sixth, seventh, and ninth in the west, south, and north, respectively. Comparison of the percentage of the average precipitation in the 3 years of deficient, and the 3 years of greatest, precipitation in Puerto Rico, with a similar grouping for four divisions comprising the continental United States, is shown in table 4 below. The United States group no. 1 includes the Pacific Coast and Plateau States; no. 2 the Plains States and Missouri, Iowa, and Minnesota; no. 3 the Gulf States; and no. 4 the Northeastern States including New Jersey, Pennsylvania, and Michigan. The dependability of the annual rainfall is best indicated by its tendency to adhere closely to the normal from year to year, and it will be noted that Puerto Rico, in terms of this test, compares favorably with the United States groups, as shown in table 4. The no. 4 group of New England States with an extreme range of 49 percent is thus the most dependable of the United States groups, as Professor Henry has stated, owing to this small variation from the normal in extreme years; Puerto Rico closely approaches this figure with a range of 52 percent. Several factors may be said to favor a comparatively small range between the maximum and minimum rainfall years, one of which is the fact that the smaller the average or normal rainfall, the greater is the variation from year to year, or to state it conversely, the greater the rainfall normal, the less tendency for large variation from year to year. Inasmuch as the precipitation normals for Puerto Rico are 42 to 75 inches, representing the south and east divisions, respectively, this factor would be of some weight in explaining the smaller ranges and departures from normal shown from year to year in the island rainfall. Comparing the average deficiency for all droughts in the United States with some of the dry years in the island, the following will illustrate the smaller variations in the Puerto Rico departures.

	Percent
United States, average of all droughts	68
Puerto Rico, drought of:	
1930	79
1923	80
1907	85
1925 and 1929	88
1926	90

The comparatively small rainfall deficiency as related to the normal of course fails to give an adequate indication of the conditions making for drought in the Puerto Rico area. Distribution through the year is an important item, since heavy rains at widely separated intervals may be, in total, a near approximation of the normal, but with periods of weeks or months intervening subject to subnormal precipitation and often severe droughts. Heavy run-offs, and a high rate of evaporation due to long duration of sunshine, are factors which enter quite largely into the production of droughts, in the island, oftentimes when the percentage of departure from the normal is not notably large.

In the tabulation of continental rainfall by years, the tendency is noted for a year of abnormally dry conditions to be preceded by gradually diminishing rainfall and followed by several years of dryness. Such a trend may be similarly observed in the chronological record of Puerto Rico rainfall, to the extent, at least, that there appear to be sequences or unit groups of years with subnormal rainfall. A 5-year sequence of gradually decreasing rainfall led up to the drought of 1923 while that of 1930 was preceded by gradually decreasing precipitation in 1928 and 1929. Wet years appear frequently to come in pairs, as in 1911 and 1912, 1915–16, 1927–28 and 1931–32.

TABLE 1.—*Years of deficient rainfall (percent of normal) in order of relative dryness, Island of Puerto Rico, 1899 to 1932*

Section	Mean	1		2		3		4		5	
		Year	Percent	Year	Percent	Year	Percent	Year	Percent	Year	Percent
North	73.5	1930	76	1923	82	1925	84	1907	85	1918	87
East	75.28	1923	72	1907	74	1926	78	1915	85	1930	85
South	42.0	1929	70	1922	72	1930	72	1910	74	1923	75
West	76.9	1930	87	1923	88	1924	88	1919	89	1915	89
Island	67.4	1930	79	1923	80	1907	85	1929	88	1925	88

Section	Mean	6		7		8		9		10	
		Year	Percent	Year	Percent	Year	Percent	Year	Percent	Year	Percent
North		1929	88	1912	89	1926	89	1913	90	1920	90
East		1925	88	1917	89	1918	92	1914	94	1908	94
South		1907	80	1215	80	1917	81	1921	87	1926	88
West		1910	91	1900	91	1929	92	1905	92	1920	92
Island		1926	90	1918	91	1913	91	1921	92	1920	94

Note: Old Spanish records, San Juan, dating from 1868 show a dry period, approximating the record for 65 years in 1873, annual rainfall 68 percent of the normal and in 1893 67 percent of normal. Canovanas record 1890–98 also has record dry period, 1893 68 percent.

TABLE 2.—*Years of greater than normal rainfall (percent of normal) in order of relative depth, Island of Puerto Rico, 1899 to 1932*

Section	Mean	1		2		3		4		5	
		Year	Percent	Year	Percent	Year	Percent	Year	Percent	Year	Percent
North	73.5	1901	134	1927	132	1931	127	1916	122	1915	117
East	75.2	1931	143	1901	137	1909	125	1916	121	1932	121
South	42.0	1909	148	1931	143	1902	138	1916	134	1900	133
West	76.9	1928	129	1901	127	1927	114	1912	114	1931	111
Island	67.4	1901	131	1931	128	1916	121	1927	120	1902	118

Section	Mean	6		7		8		9		10	
		Year	Percent	Year	Percent	Year	Percent	Year	Percent	Year	Percent
North		1902	115	1899	110	1909	108	1932	108	1928	107
East		1902	120	1905	117	1927	117	1904	115	1924	110
South		1912	124	1932	124	1899	123	1928	122	1901	118
West		1932	110	1904	108	1899	108	1914	106	1902	106
Island		1909	116	1928	114	1932	112	1899	110	1911	107

TABLE 3.—*Percentage rainfall departure from normal by sections: Puerto Rico, 1899–1932*

Year	North	East	South	West	Island
	Percent	Percent	Percent	Percent	Percent
1899	110	102	123	108	110
1900	101	109	133	91	104
1901	134	137	118	127	131
1902	115	120	138	106	118
1903	94	99	107	103	98
1904	93	115	109	108	101
1905	94	117	108	92	100
1906	96	96	97	98	96
1907	85	74	80	94	85
1908	93	94	96	93	94
1909	108	125	148	100	116
1910	101	98	74	91	95
1911	106	107	113	103	107
1912	89	96	124	114	103
1913	90	96	94	93	91
1914	93	94	91	106	89
1915	117	85	90	89	102
1916	122	121	134	97	121
1917	104	89	81	97	97
1918	87	92	93	99	91
1919	98	99	100	89	97
1920	90	96	104	92	94
1921	90	99	87	101	92
1922	91	95	72	106	88
1923	82	72	75	88	80
1924	104	110	111	88	105
1925	84	88	80	106	88
1926	89	78	88	99	90
1927	132	117	104	114	120
1928	107	109	122	129	114
1929	88	105	70	92	88
1930	76	85	72	87	79
1931	127	143	143	111	128
1932	108	121	124	110	112

TABLE 4.—*Percentage of the average precipitation in the 3 years of deficient and the 3 years of greatest precipitation in the groups of States, no. 1 to 4, and in Puerto Rico*

Groups	Least			Greatest			Range
	1	2	3	1	2	3	
No. 1	59	65	67	167	149	136	108
No. 2	64	72	77	143	133	129	79
No. 3	74	77	82	136	126	123	62
No. 4	78	83	84	127	120	116	49
Puerto Rico	79	80	85	131	128	121	52

TABLE 5.—*Comparative data on the rainfall in Puerto Rico during 1932, by sections, inches rainfall, and percent of normal*

	North		East		South		West		Island	
	Inches	Percent	Inches	Percent	Inches	Percent	Inches	Percent	Inches	Percent
January	6.36	131	4.62	121	1.02	71	2.60	111	4.26	121
February	.67	18	1.44	42	.48	26	.70	28	.71	24
March	2.71	66	3.40	103	1.63	97	2.29	63	2.44	72
April	4.34	87	6.89	181	2.60	107	5.04	85	4.30	97
May	11.70	175	10.02	149	10.60	283	14.23	180	11.96	188
June	8.26	145	10.65	148	6.98	190	5.02	68	7.58	134
July	5.90	81	11.13	153	2.25	60	8.79	107	6.07	92
August	6.46	94	9.17	128	7.58	164	11.76	129	7.96	117
September	11.57	155	9.58	104	6.69	118	17.11	182	11.28	149
October	7.21	103	9.63	102	4.20	65	9.75	100	7.21	94
November	6.80	84	7.82	88	4.85	104	5.11	69	6.11	85
December	6.38	104	6.46	131	3.14	174	2.23	68	4.83	109
Year	78.36	108	90.81	121	52.02	124	84.63	110	74.71	112

STORM TYPES AND RESULTANT PRECIPITATION IN THE SAN DIEGO AREA

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At the request of engineers and water conservationists of southern California, who are not satisfied with the rate and intensity alone of the rainfall but wish also to know something of its origin, tables were prepared which segregated storms in San Diego County into four groups according to their genesis. Weather maps of the north Pacific Ocean are available in San Diego for only the last 5 years, hence the data could not be carried back farther than 1929.

From available weather-reporting stations in San Diego County, 3 were selected, San Diego, 87 feet elevation, Cuyamaca, 4,677; and Warner Springs, 3,165. The criteria were length and dependability of record, elevation, and surrounding topography. San Diego was considered as representative of the coastal, Cuyamaca the mountain, and Warner Springs the intermediate rainfall regimes. Warner Springs in particular is well located for a rainfall study, for it is surrounded in all directions by moderately high mountains, and the effects of the dynamical or ascensional cooling of the rain-bearing winds here are nearly equal, regardless of the direction from which they come. On the other hand, the rain gage at Cuyamaca is exposed in a draw, and records very heavy rains when winds are from the southwest quadrant. In fact, it is located at one of the rainy spots of southern California.

From data of the three stations, three tables have been compiled: (1) The total number of days and amounts of